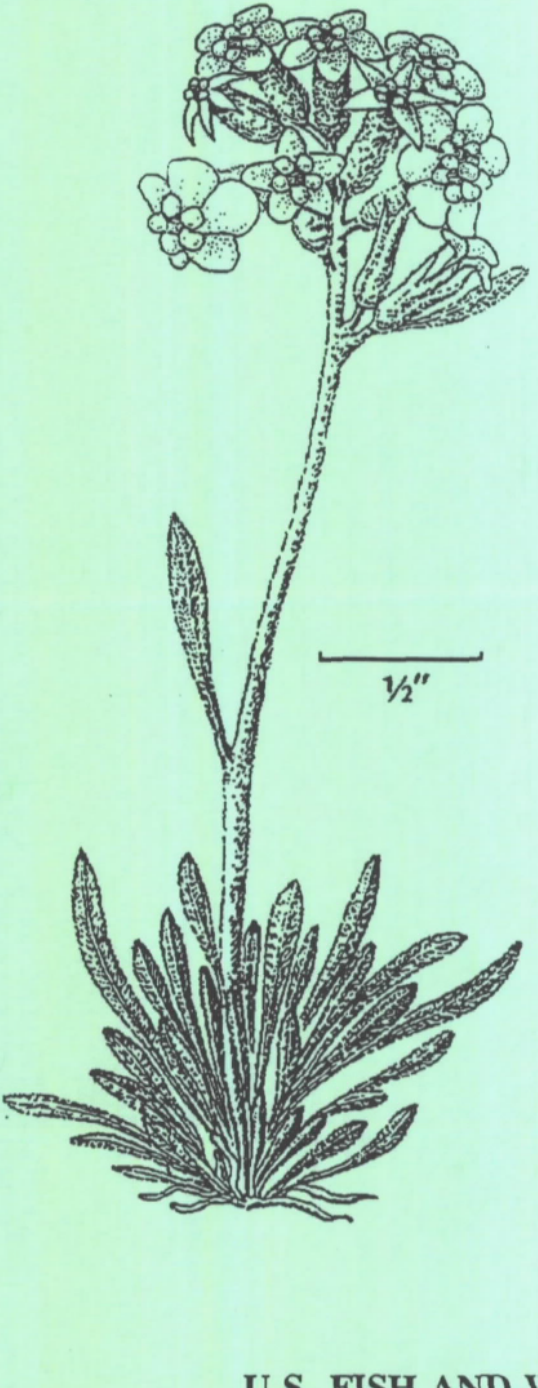
Terlingua Creek Cat's-eye Recovery Plan
(*Cryptantha crassipes*)



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TERLINGUA CREEK CAT'S-EYE

Cryptantha crassipes

RECOVERY PLAN

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Regional Director, U.S. Fish and Wildlife Service

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LITERATURE CITATIONS

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EXECUTIVE SUMMARY OF THE TERLINGUA CREEK CAT'S-EYE RECOVERY PLAN

Current Species' Status: The Terlingua Creek cat's-eye is listed as endangered. It is known from 10 sites within a six-mile (10 kilometer) radius in west Texas. Less than 5000 plants are known.

Habitat Requirements and Limiting Factors: The Terlingua Creek cat's-eye grows on xeric, barren, gypsiferous, low rounded hills and gentle slopes composed of small platelets of silty limestone in the Trans-Pecos shrub savannah. The species is threatened by off-road vehicle use, road maintenance, and residential development. It is particularly vulnerable due to narrow habitat specificity, extremely limited distribution, and low numbers of individuals.

Recovery Objective: Delisting.

Recovery Criteria: Develop and implement management plans that insure the long-term protection and stability of a minimum of three population centers. There should be a total of at least 20 viable populations across the three population centers with each population comprised of no fewer than 1000 plants and being capable of long-term, self-perpetuating reproduction.

Major Actions Needed:

1. Establish protected sites and develop management plans.
2. Maintain reserve seed bank/cultivated populations.
3. Gather biological information necessary for management decisions.
4. Search for new populations.
5. Develop plans for augmentation and/or establishment of new populations, if feasible, at suitable sites.

Total Estimated Cost of Recovery ($000's):

Year	Priority 1	Pr 1•	Pr 2	Pr 3	Total
1994	41.5	40.5	76.5	2.5	161
1995	32.5	35.5	66.0	.75	134.75
1996	24.5	29.5	49.75	.75	104.5
1997 to 2023 (TOTAL)	304.0	30.5	398.5	28.5	761.5
Total	402.5	136.0	590.75	32.5	1161.75

Date of Recovery: If continuous progress is made, populations should be at recovery levels in 20 years. Delisting could be initiated in 30 years (2023) if populations are sustained at recovery levels for 10 years.

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I. INTRODUCTION AND BACKGROUND

A. Brief Overview

The Terlingua Creek cat's-eye (*Cryptantha crassipes*) was Federally listed as endangered on September 30, 1991 (U.S. Fish and Wildlife Service 1991). No critical habitat was designated because it was not considered prudent. *Cryptantha crassipes* has a recovery priority of 5C. Recovery priorities for listed species range from 1 to 18, with species ranking 1 having the highest recovery priority. A recovery priority of 5C indicates that this is a full species with a high degree of threat, a low recovery potential, and in conflict with a development project (U.S. Fish and Wildlife Service 1983a, 1983b).

Cryptantha crassipes belongs to the Borage (Boraginaceae) family. The stems of this silvery erect perennial arise from a mound of hairy, grayish leaves, and are topped with clusters of white flowers with bright yellow centers. The species was first discovered by V. L. Cory in the late 1930s, and described shortly thereafter by I. M. Johnston (Johnston 1939).

Known only from an area within a six-mile (10 kilometer) radius in Brewster County in west Texas (Figure 1), the species is endemic to a rare and unique geologic formation composed of creamy yellow platelets of silty limestone which is almost devoid of vegetation and has a high level of gypsum. No plant is abundant in this harsh, xeric habitat, and *C. crassipes* is at best locally common at a few sites. Due to the species' remoteness and extremely limited range, research has been limited, and almost nothing is known concerning the biology of the species (Poole 1987).

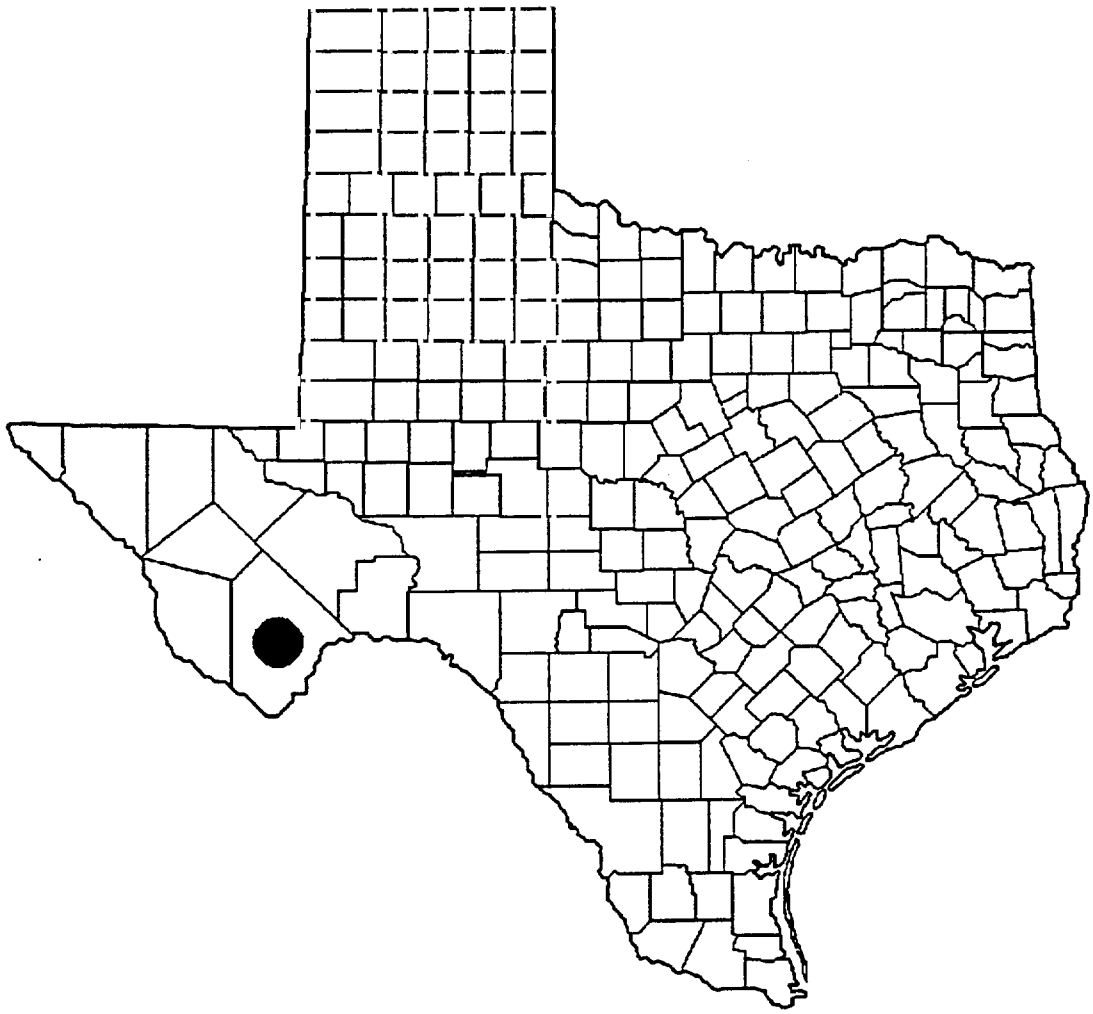

Figure 1. Distribution of Cryptantha crassipes

Ten sites with almost 5000 individuals total are known. All are on private land in an area of complex ownership due to a local resort development. Population sizes range from 50 to approximately 2000 individuals. Habitat areas vary in size from small patches of 5 acres (2 hectares) to large sites of over 500 acres (202 hectares).

The greatest threat to Cryptantha crassipes is habitat alteration and destruction. Off-road vehicle use, road development and maintenance, and residential development are contributors to this threat. The rarity of the unique geologic sites combined with the species' narrow habitat specificity, extremely limited distribution, and low numbers of individuals serves to amplify the threat from habitat destruction. As more of this scarce habitat is destroyed, there will be fewer suitable places for the species to exist and less chance for survival.

B. Taxonomy

Cryptantha crassipes was first collected by V. L. Cory in the late 1930s in Brewster County, Texas. Dr. I. M. Johnston described the species in 1939 and placed it in the section Oreocarya (a taxonomic group). This group has been the subject of several studies, and all have treated C. crassipes as a distinct species.

C. Morphology

Cryptantha crassipes is a distinctive plant. Erect stems protrude from a mound of hairy, silvery leaves and are topped with clusters of white flowers with knobby, bright yellow centers. Other species of Cryptantha in the area have their flowers scattered along the stems and plants tend to be more elongate and taller. The seeds of C. crassipes are unique in the genus, and mature seeds are the definitive means of identifying poorly collected or fragmentary specimens.

The species is a silvery perennial 15-25 centimeters (6-10 inches) tall. A dense mound of leaves develops on top of a woody base. The leaves are narrowly lance-shaped, more or less pointed, and covered with a copious amount of tiny white hairs and bristles. The lower leaves are up to 6 centimeters (2.5 inches) long and 7 millimeters (0.3 inches) wide, becoming smaller up the slender stems. The erect stems are hairy, bristly, and as tall as the plant. At the tips of the unbranched stems are flower clusters up to 2.5 centimeters (1 inch) in diameter. The bristly hairy calyx increases to 11 millimeters (about 0.5 inch) in fruit. The slender cylindrical corolla tube is 8-9 millimeters (about 0.3 inch) long and abruptly expands into a flat five-lobed limb, which is about 2 millimeters (about 0.1 inch) wide. The corolla is white with bright yellow knobs arising amongst the laid-back lobes. The flowers are dimorphic and heterostylic; that is, there are two forms of flowers: one with short stamens and long styles, and the other with long stamens and short styles. The fruit is composed of four seeds (nutlets). The gray nutlets are egg-shaped, shiny, and almost smooth. Each nutlet is 2.8-3.8 millimeters (0.1-0.15 inch) long and 2.5-3 millimeters (about 0.1 inch) wide.

D. Distribution, Abundance, and Land Ownership

The ten known sites are scattered within a six-mile (10 kilometer) radius in the drainage of upper Terlingua Creek in Brewster County, Texas. While these are the only confirmed localities, the species has also been reported from Big Bend National Park (anonymous written observation on pre-1990 plant list), east of Lajitas (plant fragment), and Otero County, New Mexico (incomplete specimen). Suitable habitat may yet be located in the Big Bend National Park area or Big Bend Ranch State Natural Area which would extend the range of this rare plant westward to the Big Bend area (J. Poole, Texas Parks and Wildlife Department, pers. comm.). No populations have yet been located in the area.

Little of the habitat within the known 100 square mile area is suitable for Cryptantha crassipes, as the unique geologic formation it requires is not pervasive. Populations occupy sites from 5 to over 500 acres (2 to 202 hectares) in size (average = about 100 acres, or 40 hectares), and numbers of individuals within populations vary from 50 to approximately 2000 (average = about 450). The resulting densities range from 1 to 124 plants per acre (2 to 272 plants per hectare), with the average population density being approximately 4 plants per acre (9 per hectare). Only two of the densities are over 10 plants per acre (22 plants per hectare), and 7 of the populations have a density of 5 or fewer plants per acre (11 per hectare) (Table 1). The above figures rely on visual observations and approximations and should be confirmed by actual measurements within the habitat. Due to the long-lived perennial nature of the species, the apparently low and/or erratic recruitment, and the brief length of study, it is not known whether populations are stable, increasing, or declining.

Table 1. Summary of known populations of Cryptantha crassipes

site	# indivs	size in acres (hectares)	density # of individuals per acre(hectare)
1	500	105 (48)	5 (10)
2	2000	65 (30)	31 (68)
3	620	5 (2)	124 (272)
4	84	10 (5)	8 (18)
5	50	10 (5)	5 (10)
6	500	175 (80)	3 (6)
7	100	60 (27)	2 (4)
8	100	55 (25)	2 (4)
9	500	540 (245)	1 (2)
10	100	65 (30)	2 (3)
Total	4554	1090 (495)	4 (9)

All known sites are located on privately owned land. Land ownership in the area is very complex due to the division of many tracts into 5, 10, and 20 acre (2, 4, and 8 hectare) parcels. Much of the property is held by absentee owners. The maintenance authority for the numerous roads is unknown. Within the last several years underground telephone cables were installed along some of the roads.

E. Life History

In a xeric habitat with erratic precipitation, one of the best life history strategies is that of a long-lived perennial such as Cryptantha crassipes. Plants often appear to be quite old, as evidenced by their extremely woody bases with numerous clumps of leaves and stems, and their large size (up to 1 foot, or 30 centimeters, in diameter).

Flowering can begin as early as late March and continue until early June. Lack of rain and high temperatures often end the flowering season prematurely with flowers shriveling and fruits aborting. Another complication in the reproductive biology of the species is the presence of dimorphic, heterostylic flowers (flowers of two forms, some with short styles and some with long styles). There has been some disagreement in the past over whether heterostyly actually exists (reported by Johnston in 1939, but refuted by Higgins in 1971). Recent study by Hughes (1992) has confirmed heterostyly, and he found the two forms in approximately a 1:1 ratio. Such heterostyly suggests that the species is an obligate outcrosser, thus requiring some sort of pollinator. Although the exact identity of the pollinator(s) is not known, preliminary studies indicate that the agents are small bees (Hughes 1992). Often insects that pollinate desert endemics are as rare as the species they frequent (Hughes 1992). Effective seed set could be hampered by these two factors (an obligate outcrosser, pollinated by a rare insect).

The seeds are small, dry, and lack any sort of wings or fluff. Dispersal is probably carried out by water, insects, or small mammals. Nothing is known concerning the in situ (natural habitat) seed biology of this species. In other members of the genus, germination and seedling establishment occur during the late summer and early fall when rainfall is at its peak, then

during the winter and early spring seedling mortality is common due to drying winds and low moisture (Sivinski, New Mexico Department of Energy, Minerals and Natural Resources, Santa Fe, New Mexico, in litt., 1990). No seedlings or juvenile plants of Cryptantha crassipes have been reported from natural habitat sites. How long individual plants live is not known; nor is the cause of their mortality.

F. Habitat

Cryptantha crassipes grows in an arid, subtropical climate with cool, dry winters and hot, dry summers. What little precipitation falls, occurs primarily in the late summer. Evaporation exceeds precipitation, and daily temperature fluctuations are great. The nearest weather station, in the Chisos Basin, does not approximate site conditions for the cat's-eye. The approximately 2000 foot (606 meter) higher elevation in the Chisos Basin creates significant differences in the precipitation and temperature. The station at Presidio, though almost twice as far away and at a lower elevation than the cat's-eye by over 1000 feet (303 meters), has a more similar climate. The following climatic data is from the Presidio weather station. Winter low temperatures average 33-34°F (0.5-1°C), while summer high temperatures average 102-103°F (39°C) (Bomar 1983). The all-time low temperature in Presidio was 4°F (-16°C), while the record high temperature of 117°F (47°C) has been reached several times (Bomar 1983). The frost-free period is normally from mid-March to mid-November with an average of 44 freeze occurrences per year (Bomar 1983). Presidio has an average of 88 days per year over 100°F (38°C), a state record (Bomar 1983). Average annual precipitation is 9.2 inches (23.4 centimeters) with the highest amount occurring in the late summer (Bomar 1983).

The local microclimate at known sites is influenced by the light-colored ground surface and lack of vegetation. Temperatures above ground level are probably increased due to reflectance while below ground temperatures might be slightly cooler. Lack of vegetation precludes any temperature reduction from shade, and probably produces lowered humidities.

All known sites occur on the Fizzle Flat lentil, a hard, creamy yellow, platy, impure silty limestone which breaks down

into small, angular, uniform fragments (Moon 1953). This impure limestone is believed to have a high level of gypsum. All known sites are mapped as the Badlands-Vieja association by the Soil Conservation Service (1973). The Badlands are described as desolate barren areas exposed by geologic erosion. The species occurs on rounded, low hills and gentle slopes at no particular aspect. Site elevations vary from 3150 to 3450 feet (955 to 1045 meters).

Vegetation is sparse in this habitat, probably due to a high gypsum content in the substrate. Vegetation cover is less than 10%. Most of the species present are shrubs and woody perennials, and several have a low, rounded growth form. Many of the species are gypsophilic. According to Kuchler (1964), this area is within the Trans-Pecos shrub savannah. However, local edaphic conditions have created a community dominated by rough tiquilia (Tiquilia hispidissima), Havard wild buckwheat (Eriogonum havardii), and gyp machaeranthera (Machaeranthera wrightii). This unusual habitat includes several other species in addition to Cryptantha crassipes that are considered rare and are species of special concern in Texas, including bushy wild buckwheat (Eriogonum suffruticosum), perennial spurge (Euphorbia perennans), and Chihuahua ringstem (Anulocaulis leiosolerus var. lasianthus). Other common species in the habitat include Schott's acacia (Acacia schottii), longstalk greenthread (Thelesperma longipes), tubular slimpod (Amsonia longiflora), shaggy stenandrium (Stenandrium barbatum), creosote bush (Larrea tridentata), feather dalea (Dalea formosa), range ratany (Krameria glandulosa), ephedra (Ephedra sp.), and damianita (Chrysactinia mexicana).

G. Impacts and Threats

Conditions or activities that destroy the habitat of Cryptantha crassipes threaten the species either by eliminating individuals necessary to maintain a stable population or by reducing the amount of the unique habitat, already in short supply, that is required by the species.

In the past, the habitat of Cryptantha crassipes was unfragmented except for natural differences in geology. Now ranch tracks and numerous subdivision roads have been blazed across the area, probably destroying some plants in their path and fragmenting the habitat and some populations. These routes have also opened the way for modern recreational use (off-road vehicles ((ORVs)), mountain bikes, hiking and horseback riding groups). Although road maintenance is minimal and few tracks have been observed in the habitat, the area lacks any fencing or gates to confine wheeled vehicles. Tracks and roads take scores of years to disappear in this extremely arid environment.

The current number of permanent human occupants in the 100 square mile (290 square kilometer) area that supports Cryptantha crassipes is very small. However, a significant portion of the known individual plants are on various 5, 10, and 20 acre (2, 4, and 8 hectare) tracts sold by a local resort developer. Most property owners are absentee and there is little activity on the properties at present. The potential for habitat destruction, if owners develop these tracts, is a threat to some plants.

Cryptantha crassipes is particularly vulnerable to impacts and threats because of its narrow habitat specificity, extremely limited distribution, and low numbers of individuals. The species is found only on an uncommon rock formation, which is scattered within the geologic mosaic of the Big Bend region.

Much apparently suitable habitat within the species' range is not currently occupied, but may present usable habitat the species is capable of colonizing. The small occupied area and low numbers make the species vulnerable to chance extinction events from disease, natural or man-caused catastrophes, genetic drift (loss of genetic variability and thence adaptability), etc. In addition, the habitat is quite arid, which in many growing seasons may limit the species from reaching its full reproductive potential. If numbers fall below critical levels, populations may no longer be able to survive cycles with several seasons that do not allow successful reproduction.

Pollinators are potentially very important. The species is likely an obligate outcrosser reliant on insects that are probably also narrow endemics (known only from a limited geographic area). Conditions or activities that harm these pollinators could secondarily harm Cryptantha crassipes.

H. Conservation and Research Efforts

Conservation: The only conservation measure initiated so far is seed storage collection. The National Seed Storage Lab in Fort Collins, Colorado contains 200 field-collected seeds and the Desert Botanical Garden in Phoenix, Arizona retains 820 field-collected seeds.

No formal agreements or management plans have been developed with the various landowners for site protection and management.

Research: Barry Hughes, a graduate student at Sul Ross State University, has begun studies on the reproductive biology of Cryptantha crassipes, about which little is known. Preliminary studies (Hughes 1992) indicate that the species is pollinated by small bees, which themselves may be endemic to the Chihuahuan Desert region and possibly rare and restricted to the same habitat as Cryptantha crassipes. Hughes (1992) has also made counts of the two flower forms (about 1:1), sketched a rough map of individuals and the population, and analyzed the nectar and pollen. Hughes also propagated 98 plants from seed in a greenhouse setting, and under these optimal conditions obtained three flowering individuals in two years. He has reported germination rates of about 75% and 40-50% in two trials and has developed some simple techniques to increase success in transplanting seedlings (Hughes, pers. comm., 1993) during cultivation studies.

The Desert Botanical Garden in Phoenix, Arizona, working with the Center for Plant Conservation, has performed two germination experiments to determine the best growing medium for germination and seedling growth (Pritchett-Kozak and Ecker 1992). Germination rates were 0% in two treatments and 5.56%,

34.48%, and 57.14% in one treatment each. Germination was found to be slow and sporadic, occurring from 34 to over 76 days after planting. Lower nighttime temperatures (58-62°F, or 14-17°C) appear to enhance germination.

Both research groups have found that the species is susceptible to transplant shock, although Hughes has had better success by refrigerating plants for a few hours prior to transplanting. Also, the seedlings are very sensitive to watering and must be kept relatively dry and never misted or watered over head.

I. Recovery Strategy

Cryptantha crassipes populations are so few and distributed over a small enough geographic area that the species is vulnerable to extinction from catastrophic events. The situation for this species is even more precarious because it is restricted to a very limited and fragmented rock formation, has a very low density per site, occurs in arid environments slow to recover after damage, and is in an area under development pressures that present a variety of threats.

To prevent extinction in the wild it is necessary to protect known populations from damage or destruction. In the absence of special agreements or easements, private lands provide less assurance of protection than public ownership and management, due to the possibility of property transfers and land use changes. This possibility is extremely high in the resort development area as the small tracts of land are exchanged or sold at a much higher rate than adjoining property. This plan provides for protection of known populations through identifying landowners and informing them about the presence of the plants, working with landowners to establish protected sites, developing cooperative conservation programs and agreements, exploring the possibility of purchase and/or land-trades by public or private conservation agencies from willing landowners, and ensuring compliance with Federal and State laws.

Evaluations of individual populations should be made to identify any management actions needed to stabilize them and maintain vigor and viability. Because so little is known about *Cryptantha crassipes* and its needs, it will be impossible to formulate effective long-term management guidelines immediately. Interim, short-term management guidelines should be developed and implemented to preserve sites and reduce or eliminate obvious

threats. Care should be taken that interim management actions are conservative and minimal to avoid inadvertent harm resulting from a lack of information about the species, its responses to management techniques, and its needs.

Sites should be monitored carefully. Baseline information about the species is needed to address long-term management and recovery needs. Studies should be conducted on habitat, community composition, demographic structure, genetic variability, reproductive biology and phenology (the relationship of climate and seasonality to the life history stages of a plant). The stability of the populations should be evaluated as this basic information becomes available to ensure that all populations are viable and self-perpetuating.

Populations should be stabilized if necessary. If demographic structure and genetic variability are insufficient to maintain vigor and viability, augmentation through the addition of individuals or breeding manipulation should be undertaken if it is determined that it would be helpful.

Because the species appears to be vulnerable to catastrophic events, a seed bank and cultivated collection is recommended in addition to site management. Such ex situ collections should preserve the genetic variability of the species. This will require scientific studies of seed viability, longevity, and germination, as well as seedling biology and other aspects of cultivation and storage needed for an effective and well-managed conservation collection of plants and seed.

Protection and stabilization of currently known populations are insufficient for delisting of Cryptantha crassipes. To achieve the long-term goal of full recovery and delisting, additional populations would need to be found or established to prevent chance destruction of all or a significant portion of the

populations. Although more populations may be discovered, intensive survey work (Poole 1987) failed to find additional populations in apparently suitable habitat at some distance from the known occupied region. Why Cryptantha crassipes does not occur in such apparently suitable habitat should be ascertained before any reintroduction work is begun. Such apparently suitable habitats may lack adequate numbers of proper pollinators or have other deficiencies that make the sites unacceptable to the species. Suitable unoccupied habitat within the historic range of this species will have to be available before establishing new populations can be attempted. Sufficient suitable habitat for recovery through establishment of new populations may not exist. Controlled pilot studies should be conducted and carefully evaluated for feasibility before any large-scale reintroductions are attempted.

Successful reintroduction will require studies of community composition and structure, demographics, genetics, phenology and vulnerable phases of the life cycle, seed and seedling biology under field conditions, reproductive biology, seed production and dispersal, planting techniques, and other aspects of the species' biology.

The success of any program for protection and recovery for Cryptantha crassipes is dependant on the concern, understanding, and cooperation of private landowners. This need is addressed in the recommendation to establish a proactive program of landowner contact, information, involvement in site planning and management, and assistance.

II. RECOVERY

A. Objective and Recovery Criteria

Objective: The overall goal of this recovery plan is to provide sufficient safe, viable, self-perpetuating populations of Cryptantha crassipes in its natural habitat to allow the species to be removed from the list of Endangered and Threatened Wildlife and Plants.

Recovery Criteria: If additional populations are discovered or sufficient suitable habitat is available and establishment of new populations proves to be feasible, Cryptantha crassipes could be considered for delisting when a minimum of three population centers containing a total of at least 20 viable populations with each population comprised of no fewer than 1000 plants are protected.

Three population centers (metapopulations) spaced over a large enough area could insure that the species would not be threatened with extinction from a single catastrophic event. Twenty populations within these three metapopulations should hold enough genetic variation for future adaptation, evolution, and the chance loss of individuals or populations. Due to the low population density (usually less than 5 individuals per acre, or 12 per hectare) and the functional dimorphism of the flowers (effectively separate males and females), each population should contain at least 1000 individuals to allow adequate pollination and regeneration.

Presently, all populations are on private land. Although one potential introduction site is on public land, it is not known whether the species can become established at this site. The target number of populations and individuals has been

selected from the high side of known conditions to compensate for inescapable long-term losses due to changes in land ownership or management, and random events such as natural catastrophes or disease.

If continuous progress is made, populations should be at recovery levels in 20 years. Due to the long-lived nature of the species and propensity of the climate to drought, a monitoring period lasting 10 years is needed prior to delisting to assure that the populations are self-perpetuating (that is, viable and reproductive). Delisting could be initiated in 30 years (2023) if populations are sustained at recovery levels for 10 years.

These delisting criteria are preliminary and subject to revision based on new information (including research specified as recovery tasks in this plan). As information is acquired and evaluated, and recovery tasks are accomplished, the above criteria will be reevaluated and modified as necessary.

B. Recovery Outline

The following is an outline of the recovery tasks needed to attain the objective of this plan. The following section (Narrative Outline of Recovery Actions) includes more detailed information on the tasks.

1. Establish protected sites for Cryptantha crassipes and develop management plans

    11. Identify all owners of lands that support populations and/or individuals of Cryptantha crassipes

    12. Communicate with landowners to explain the presence and importance of Cryptantha crassipes, to determine current and intended land use, to offer assistance and advice, and to enlist interested parties in a cooperative program

        121. Work with landowners to establish sites protected from existing and future threats

        122. Collaborate with landowners to establish short-term management plans that adequately protect and stabilize the species

        123. Work cooperatively with landowners to develop and implement a long-term management plan for each population

    13. Explore the possibility of land trade or purchase from willing sellers at fair market value of tracts supporting significant numbers of Cryptantha crassipes

14. Ensure compliance with applicable Federal and State laws and regulations

15. Monitor populations for general condition, reproductive success, and other factors that would assist in management

16. Assess and revise management plans regularly to address the needs of the species and the landowners

2. Maintain cultivated populations and seed storage banks with responsible agencies and/or institutions

21. Develop, establish, and coordinate a conservation collection and research program

211. Collect propagative materials

212. Maintain and monitor propagative materials

213. Conduct research based on needs and opportunities of the program

214. Develop data collection guidelines and promote information sharing

215. Plan for the dissemination and disposal of live plant material

22. Coordinate and incorporate results from propagation program with other research efforts

3. Conduct studies to gather information needed for management

31. Determine exact habitat requirements

311. Evaluate climate

312. Determine exact geologic and edaphic features

313. Study community structure and associated species

314. Determine critical community/habitat dynamics

3141. Determine successional stage

3142. Evaluate species dependence on natural phenomena

3143. Study the response of the species to disturbance

315. Study beneficial and negative interactions with other species

32. Study population biology

321. Evaluate present conditions and determine requirements for maintaining viable populations

3211. Assess present demographic composition and determine viable population structure

3212. Assess present genetic composition and determine requirements for genetic viability

322. Describe phenology and identify critical stages

323. Determine reproductive biology

3231. Study pollination biology

3232. Ascertain modes of reproduction and the contribution of each type to the population

3233. Examine aspects of seed biology including development, production, viability, dormancy, longevity, dispersal, and germination in the natural habitat

3234. Study seedling biology and ecology in the natural habitat

33. Study cultivation requirements

331. Examine characteristics of seed biology including viability, longevity, dormancy, and germination requirements under controlled conditions

332. Delineate cultivation techniques from seedling to reproductive adult stages and identify critical phases

333. Investigate other propagation techniques

4. Identify and search potential habitat

41. Identify potential habitat through use of maps, photographs, and knowledgeable individuals

42. Survey identified sites for existing populations and potential sites for establishment of new populations

5. Evaluate the feasibility of augmentation and/or establishment of new populations

51. Determine if known populations require augmentation and if the habitat can support more individuals

52. Develop and establish an experimental program for augmentation and/or establishment of new populations

53. Monitor experimental program results and evaluate the feasibility of augmentation and/or new population establishment on a larger scale

6. Initiate an augmentation and/or new population establishment strategy, if required and feasible

7. Encourage public interest and concern for the species and its preservation

8. Develop a post-recovery monitoring plan

C. Narrative Outline of Recovery Actions

1. Establish protected sites for Cryptantha crassipes and develop management plans. Cryptantha crassipes occupies an extremely small area in a habitat that is itself highly restricted. The presence of gypsum along with the arid, frequently drought-ridden, climate leads to low plant densities on known sites. Because of the harshness of the habitat, C. crassipes has few populations (and thus relatively few individuals). In populations with low numbers of individuals, each individual may be an important component of the population. There may be a precarious balance to maintain not only enough individuals to sustain a population, but enough populations to sustain the species. Damage or destruction of individuals or populations might be enough to tip this delicate equilibrium into a downward spiral and eventual extinction. Thus every site needs protection. At present all known populations are on private land. Because land ownership and subsequent management practices often change through time, protection of such sites is somewhat more difficult. However, by using management agreements, conservation easements, and other tools, plans can be developed that are beneficial to the landowners as well as the species. Landowner cooperation is an integral component in the recovery of this species. Owners of property that the species occupies and the resort development should be encouraged to protect the species and commended for their efforts.

11. Identify all owners of lands that support populations and/or individuals of Cryptantha crassipes. Although Cryptantha crassipes occurs in an extremely limited area, the pattern of land ownership is quite complex.

Most populations are found on sites that have been subdivided into small tracts by a local resort developer. A typical population might occur on several properties, each with a different owner. All owners, with few exceptions, are absentee. Property line indicators such as fences, gates, or signs, are almost non-existent. Dirt roads are the primary delineators of property boundaries, at least among the small acreage owners. Ownership needs to be determined by checking records not only at the county courthouse but also at the office of the resort developers, if possible.

12. Communicate with landowners to explain the presence and importance of Cryptantha crassipes, to determine current and intended land use, to offer assistance and advice, and to enlist interested parties in a cooperative program. Once landowners are identified, they should be notified both by mail and by telephone of the presence of Cryptantha crassipes on their property. The rarity and importance of the species, as well as the unique nature of the surrounding natural community and geology should be stressed. They should be reassured about conservation agencies' concerns and plans, and receive an explanation of how the Federal and State endangered species laws pertain to their situation. Landowners should be queried concerning their current and intended use for the property, and offers of assistance and advice involving the biology and fragility of the species and its distinctive habitat should be given. Any landowners interested in working with the various agencies and organizations consigned to work with endangered plants should be encouraged to enter cooperative programs. All

landowners should be kept abreast of new developments concerning the status and biology of the species.

121. Work with landowners to establish sites protected from existing and future threats. As all known sites are privately owned, the fate of this species lies to a great extent in the hands of the landowners. All existing or future threats to the species should be elucidated for property owners. Landowner participation should be encouraged in establishing protection for as many sites as possible. If site protection for the species requires actions such as erecting physical barriers, signage, etc., landowners should be offered assistance in establishing such protection.

122. Collaborate with landowners to establish short-term management plans that adequately protect and stabilize the species. Short-term management needs should be identified promptly to sustain the species while long-term management plans, which may require results from future research, are being developed. Short-term management plans should include an inventory of each plant's location and condition on a tract-by-tract basis, as well as the identification and prompt removal of easily corrected threats. The setting for short-term management is at the tract or landowner level, with plans developed for each individual site. Recommendations for the elimination of any threats that can be easily and quickly resolved should be developed with the landowner. Any assistance required by the landowner for specific management tasks needed to protect and maintain

the species should be provided or located by conservation agencies.

123. Work cooperatively with landowners to develop and implement a long-term management plan for each population. As the species receives protection and easily resolved threats are promptly removed, the development of long-term management plans and any research necessary for their formation should be instituted. The goal of such long-term planning for all populations is to insure that viable, self-perpetuating populations persist in the natural habitat to guarantee the long-term survival and evolutionary potential of the species. The objectives of long-term management require input from both researchers and landowners. Because the setting of the long-term management plan is at the population level, the involvement and consensus of several landowners may be necessary. Cooperative landowners should be given assistance and advice as to the implementation of the long-term management objectives.

13. Explore the possibility of land trade or purchase from willing sellers at fair market value of tracts supporting significant numbers of Cryptantha crassipes. Many individuals of Cryptantha crassipes occur on small tracts with absentee landowners, and many have never visited their property, perhaps only holding it for investment. As in many similar situations, property turnover is high. If, after initial landowner contact and tract assessment, a property is found to support significant numbers of the species, the landowner should be approached about the possibility of sale or

trade of the parcel. Land trades occur frequently on the resort development area. If an owner of a significant property for preservation of Cryptantha crassipes preferred a land trade rather than a sale, many other pieces of desirable but less biologically significant land are available for sale within the resort development or in the surrounding area. These other tracts could be purchased to use as trades. Owners whose tracts do not include Cryptantha crassipes, but are concerned about its preservation, might be willing to trade their holdings for tracts containing Cryptantha crassipes, and either protect the plants themselves or offer the property to a government or private conservation entity for protection.

14. Ensure compliance with applicable Federal and State laws and regulations. All Federal and State laws concerning commercial trade and federally reviewed activities that might threaten the species should be enforced. If willing, landowners should be assisted in posting their property to discourage trespassing and encouraged to enforce trespassing laws where doing so will assist in addressing threats from off road vehicles.

15. Monitor populations for general condition, reproductive success, and other factors that would assist in management. All populations should be monitored on a regular basis to provide input for assessing management practices and to keep track of the overall status of the species. Monitoring frequency should be high in the initial stages of recovery, and at least include annual visits during flowering, fruiting, dispersal, and establishment. Once information is known concerning the crucial aspects in the reproductive

biology of the species, monitoring can be assigned to those times. All populations should be monitored at the same time, employing the same methodology. Thus, comparisons between populations might distinguish between natural environmental fluctuations and induced stress or decline. At a minimum, initial data collected should include numbers of individuals and their condition, numbers of seedlings, number of individuals flowering, sex ratios of flowering individuals, and seed production.

16. Assess and revise management plans regularly to address the needs of the species and the landowners. Both short-and long-term management plans should be assessed initially on an annual basis, or more often if the need arises. After additional information is gathered on the biology of the species and incorporated into long-term management plans, assessments and revisions should become less frequent. All responsible interests including agencies, landowners, researchers, etc. should be involved in the review and, if necessary, revision, to receive the benefit of each other's knowledge and expertise. Management plans should be assessed, and possibly revised, if ownership or land-use changes occur. If monitoring reveals a significant decline in the population due to management practices or the lack thereof, all involved parties should be notified. A coordinated revision of the management plan should be developed to alleviate and reverse the decline.

2. Maintain cultivated populations and seed storage banks with responsible agencies and/or institutions. Although preservation of Cryptantha crassipes in its natural habitat is the highest priority, the extremely small range, limited

amount of habitat, and low numbers of individuals, make it essential to maintain the species in artificial environments, should a catastrophic event destroy or significantly damage the natural population. Propagated populations also provide material for transplantation and research which might otherwise be taken from the wild, possibly harming the species. At least two seed storage banks and two cultivated populations should be sustained to increase the odds against chance loss of stored or propagated material. All cultivated and seed storage material should be housed with responsible agencies or institutions that maintain scientifically accurate records of cultivation and storage methods. Collections from the natural habitat should be planned so that they do not significantly lessen the species' reproductive output or interfere with other research. Seeds are currently in storage at the National Seed Storage Lab in Fort Collins, Colorado and the Desert Botanical Garden in Phoenix, Arizona. These collections should be maintained to ensure the species' survival. The species is presently in cultivation at Desert Botanical Garden and Sul Ross State University in Alpine, Texas. Both cultivation programs should be expanded and asked to address the following recovery actions (tasks 211-215, 22, and possibly tasks 331-333).

21. Develop, establish, and coordinate a conservation collection and research program. A conservation collection and research program with realistic goals and specific, measurable objectives, should be developed and coordinated by the involved agencies and institutions. Programs should go beyond maintaining genetically diverse material for possible transplantation and conducting research to offer critical insights into the reproductive biology of the

species not easily available in the field. The program should include the following recovery actions (tasks 211-215).

211. Collect propagative materials. Two major objectives in the collection of propagative materials are to cause minimal impact to the natural population while also acquiring the maximum naturally occurring level of genetic diversity. Guidelines for conservatively obtaining propagative materials with maximum genetic diversity, such as those developed by The Center for Plant Conservation (1991), should be followed. The acquisition of maximum genetic diversity is important to maintain the adaptive and evolutionary potential of the species and to provide a selection of genotypes for possible augmentation and/or establishment of new populations. Data such as that discussed in task 214 should be recorded as the material is collected.

212. Maintain and monitor propagative materials. Because propagative materials will at least initially be gathered from wild populations, and thus may momentarily diminish the species' reproductive capacity, the maintenance of such materials is very important. When feasible, seed banks represent the most efficient means of maintaining a genetically representative sample of each population. Long-term seed storage may not be feasible however, or may require frequent replenishment activities; therefore agencies or institutions should have adequate areas to house a cultivated, genetically diverse population without

exposing it to stress or possible hybridization. The agency or institution should have appropriate facilities and personnel to conduct the program, and sufficient funding and foresight to establish and maintain a long-term program. Propagative material should be monitored continually, and a report on the status should be written on an annual basis. Management plans should be put in place to provide for periodic testing and replenishment as needed. Unnecessary loss of propagative material should be avoided if at all possible.

213. Conduct research based on needs and opportunities of the program. Many aspects of seed biology, seedling ecology, and reproductive biology are barely known. Much can be learned from the routine maintenance used during seed storage and plant propagation. For example, seeds in storage are regularly checked for viability and longevity. If seeds are used for propagation, dormancy and germination requirements, percent germination under various conditions, and seedling ecology (light, moisture, and nutrient requirements) should be documented. Research on cultivated plants could provide data on phenology and reproductive biology (i.e. relationship to age and breeding systems) that should be compared to the situation in the field. It is not required that institutions maintaining propagules conduct such research but it would be efficient if such studies easily fit in with other duties. For more discussion of such research and additional studies, see tasks under 33. All research should

be adequately documented and recorded as results are available.

214. Develop data collection guidelines and promote information sharing. The importance of data collection and information sharing cannot be underestimated. Data should be collected in a scientific manner from the acquisition of propagative materials through maintenance and research to the eventual dissemination. During the collection of propagative materials detailed notes should be taken on location, date, number and type of propagules taken (including number from each parent plant and total number of parent plants), investigators' names and affiliations, and other pertinent observations (i.e., dispersal, germination, establishment, predation, etc.). If feasible, all parent plants should be identified (by map or tag), and propagules should be permanently labelled as to their parental origin. Information should be kept on all aspects of research, and reports should be written at least annually. Because at least two agencies and/or institutions will be involved with maintenance and propagation of the species, information sharing is extremely important. Frequent, informal exchanges should prevent overcollection of propagative material and needless duplication of research. Such exchange of knowledge should also allow quicker and more efficient resolutions to some of the problems prohibiting the species' recovery.

215. Plan for the dissemination and disposal of live plant material. As noted in task 212, all propagative material is of importance due to its

wild origin and unique genetic composition. Proper dissemination or disposal of live plant material requires much consideration. Any establishment of individuals or populations should be conceived, planned, and executed through a consensus of the involved parties. Permanent plantings apart from approved transplant projects and authorized cultivated collections should be carefully reviewed to decide how such actions would affect the recovery of the species. This is particularly true for any plans of commercialization. Any other disposal of live plant material should be evaluated by the regulatory agencies before action is taken.

22. Coordinate and incorporate results from propagation program with other research efforts. Hopefully the propagation program will provide much information needed for other recovery actions. All research on propagation should be made available to field investigators, agencies, landowners, and other propagators. If pertinent, the information should be used to update long-term management plans as well as the recovery plan itself. Project overlap between groups (such as laboratory seed biology studies done by both the cultivation program and seedling biology investigators) and disruption or damage of field experiments by collection of propagative materials should be avoided through communication and coordination. Applicable data gathered by field researchers should be supplied to propagation program participants to aid in their cultivation and maintenance of the species.

3. Conduct studies to gather information needed for management. Little is known concerning the precise habitat requirements, population biology, and cultivation needs of the species. To produce long-term management strategies that will guide the species toward recovery, numerous facets of the species' biology and ecology should be examined.

31. Determine exact habitat requirements. Although the habitat of Cryptantha crassipes is quite distinct, the species is not found at all similarly appearing sites. Thus, some slight differences might exist between occupied and unoccupied, but seemingly suitable, habitat. Deciphering the precise habitat requirements will be of great use in preparation and implementation of long-term management plans, as well as future searches for the species and the selection of possible establishment sites for new populations.

311. Evaluate climate. The most climatically similar weather station is located in Presidio, which is over 40 miles (64 kilometers) west and 1000 feet (303 meters) lower than the Cryptantha crassipes sites. Thus, climate at the species' sites may differ in important ways from that of Presidio. Also, the high reflectance from the light-colored ground surface may substantially affect the growth of the species. Information is needed on seasonal and daily ranges of temperature, light intensity, humidity, precipitation, and wind. Weather data are needed for the local macroclimate, as well as the microclimate in which the individual plants exist.

312. Determine exact geologic and edaphic features. Although Cryptantha crassipes seems to be

restricted to a unique geologic formation, the species does not occur on every outcropping. The geology of such sites should be compared by knowledgeable specialists to be certain that the formations are indeed the same. Depth to, and type of underlying rock formations should be checked, as well. Edaphic factors such as texture, moisture, drainage, thickness, and chemical composition should also be evaluated for differences. More detailed information on the geologic and edaphic qualities of the habitat should aid in distinguishing potential habitat for additional survey work or possible reintroduction sites.

313. Study community structure and associated species. Although species lists have been compiled for several Cryptantha crassipes sites, no quantitative work has been done. Both qualitative and quantitative vegetation surveys should be performed at each site. Data on density, dominance, frequency, and constancy of all species will be useful in determining spatial relationships within the habitat, identifying potential habitat to survey and/or reintroduce populations, and assessing long-term management plans and health of the ecosystem.

314. Determine critical community/habitat dynamics. Most knowledge of this subject is derived from assumptions based on limited visual observations. The existing plant community seems to be at a climax state and relatively stable, but the dynamics of the habitat may strongly influence where and when Cryptantha crassipes occurs. Long-

term management strategies and other recovery efforts will need information on which dynamic features of the habitat influence the species' existence and which do not.

3141. Determine successional stage. The community in which Cryptantha crassipes occurs appears to be an edaphic climax. However, the community could also be viewed as a primary successional stage in a very slow colonization process. Whether to manage the community for climax or successional vegetation is extremely important to long-term management schemes. Studies should be initiated to determine the temporal place of the community with respect to succession and the projected longevity of this phase.

3142. Evaluate species dependence on natural phenomena. Within the habitat, various natural dynamic, periodic, and/or cyclical phenomena are continually taking place. Erosion, drought, floods, heat waves, cold snaps, and population fluctuations of pollinators and predators may play significant roles in local distribution and site dynamics. Research on the degree, frequency, and duration of these events and the species' response should provide essential input for many management activities.

3143. Study the response of the species to disturbance. Erosion and flood disturbances are mentioned above under natural phenomena.

Other natural and unnatural disturbances may also be important. Recently, human-induced disturbances such as road building and ORV use have appeared in the habitat of Cryptantha crassipes. The response of the species to all types of disturbance, particularly human-caused, is a critical consideration in the development of management plans, preserve design, and long-term recovery.

315. Study beneficial and negative interactions with other species. Aside from the beneficial actions of as yet unidentified pollinators (likely small bees), nothing is known about the affects other species might have on Cryptantha crassipes. Possibly seed dispersal is performed by insects or small mammals, and the species may benefit from mycorrhizal (root fungi) associations. Identification and evaluation of the frequency, degree, and potential threat of any positive or negative interactions with other species is vitally important. Processes and phenomena such as pollination, dispersal, mycorrhiza, herbivory, seed predation, parasitism, disease, and allelopathy (chemical inhibition of one plant's growth by another) should be examined. Understanding the affects of other species on Cryptantha crassipes will allow planning to provide for species' needs in management and recovery.

32. Study population biology. Little is known about the population biology of Cryptantha crassipes aside from rough estimates of the number of individuals at a given

point in time, a fairly good approximation of the phenology (the relationship of climate and seasonality to the life history stages of a plant), preliminary identification of pollinators, and limited qualitative observations of reproductive biology and life history. Studies of the populations in their present state will provide baseline data to assess the effects of management actions, as well as distinguish them from natural environmental fluctuations. Such research will also reveal critical population thresholds, pollinator importance and vulnerability, and crucial life history stages, which, when managed appropriately, should lead to the species' recovery.

321. Evaluate present conditions and determine requirements for maintaining viable populations. Acquisition of baseline data on demographic and genetic composition for all populations is necessary for some viability and reintroduction research, and particularly important in assessing the effects of management actions. To achieve the goal of recovery (that is, protected, viable, self-perpetuating populations), understanding the factors promoting population viability is of the utmost importance.

3211. Assess present demographic composition and determine viable population structure. Although all individuals of Cryptantha crassipes appear to be at least several years old and are reproductively mature, the actual age class structure of the population is unknown. The contribution of each age class to regeneration, as well as percent survival at the various stages, should be delimited.

In these studies all individuals in a population should be mapped and assigned to an age structure category. Selected individuals should be visited at several times annually, preferably during flowering, fruiting, dispersal, germination, and establishment, to determine percent success at each stage. Determining viable population structure may take many years, as the species is quite long-lived and occurs in an environment subject to climatic extremes. Due to periodic droughts, seed production and/or establishment may be non-existent; thus longer study may be required. The resolution of viable population structure will aid in long-term management needs and strategies such as demographic augmentation and the desired demographic structure for newly established populations.

3212. Assess present genetic composition and determine requirements for genetic viability. Nothing is known concerning the genetic composition or viability of Cryptantha crassipes. Most rare species with very limited ranges have low levels of genetic variability. Sometimes this is the normal condition for a species and will not cause a decline because it has evolved reproductive mechanisms that compensate for low variability. In other species low variability is not a normal condition and, when it occurs, it may produce reduced vigor and less adaptability to environmental fluctuation. In Cryptantha crassipes the

obligatory outcrossing breeding system might be expected to lead to higher levels of genetic diversity. To maintain a viable population capable of adapting to natural environmental variation, the requisite level of genetic diversity characteristic to the species should be determined. Knowledge of the genetic identities of individuals, as well as the genetic make-up of populations, will help in cultivating genetically viable populations and in determining the necessary components for augmentation and/or establishment of new populations.

322. Describe phenology and identify critical stages. General times of flowering and fruiting are identified, but precise relation and fluctuation according to climate (particularly such events as drought, late frosts, etc.) are not. Nothing is known concerning periods of seed dispersal, germination, establishment, and dormancy. Laboratory and greenhouse experiments may identify and provide data on various crucial aspects of life history; however, all such work is done under controllable and optimal conditions. The knowledge of the precise timing of phenological events in the field is critical for the scheduling of other studies on population viability, monitoring, and reproductive biology. Plants may be more susceptible to natural and human-made disturbances during certain phenological phases. Pinpointing critical times in the natural history of the species, and determining the cause and frequency of mortality and its importance to population survival are vital in the development

of monitoring and management plans. Such knowledge will aid in determining whether natural cycles or management actions were responsible for a particular observed response.

323. Determine reproductive biology. Currently, all that is known of the reproductive biology of the species is that it is pollinated by small bees, and that it has dimorphic, heterostylic (long- and short-styled) flowers, which probably promote outcrossing. Many other aspects of reproductive biology extremely important to the self-perpetuation of the species are unknown. The examination and understanding of these features will add significant knowledge needed for cultivation, management, potential augmentation, and new population establishment.

3231. Study pollination biology. The likely pollinators have been identified as small bees, but an exact determination has not yet been made (Hughes 1992). As the species appears to be an obligate outcrosser and all reproductive parts are included within the flower, pollinators play an indispensable role. In arid climates many pollinators of endemic plants are also endemics. Thus, the pollinators of the species may also be quite rare. The identity and status of all pollinators, as well as the dependence of Cryptantha crassipes on each species, should be established. Other aspects of pollination biology such as pollen viability and pollen predation should be studied. Pollen biology research is important for management plan

development, successful cultivation, and selection of potential sites for reintroduction.

3232. Ascertain modes of reproduction and the contribution of each type to the population. The species is assumed to be outbreeding due to the presence of heterostyly. Research should be conducted to verify this assumption, and to determine if any other methods of reproduction such as autogamy (self-fertilization), agamospermy (asexually produced seeds), or vegetative reproduction are occurring. Plant age at initiating reproduction should be ascertained. The contribution and importance of each type of reproduction to the maintenance of the population should be determined. Such work is necessary for the establishment of new populations and the management of all populations.

3233. Examine aspects of seed biology including development, production, viability, dormancy, longevity, dispersal, and germination in the natural habitat. Seed biology as perceived in the laboratory or greenhouse (ex situ) may be different than that occurring under field conditions. Although such ex situ work may aid in understanding various features of seed biology, meeting in situ (natural habitat) requirements is the ultimate objective for maintaining a viable, self-perpetuating population. The amount and variation in annual seed production (particularly in

response to climate, disease, predation, or management operations), and the presence and contribution of soil seed banks are essential knowledge. Population viability studies, monitoring, and management assessments are dependent on such studies. The influence of environmental parameters such as light, temperature, moisture, substrate, etc., should be assessed for their effects on seed viability, longevity, dormancy, and germination.

3234. Study seedling biology and ecology in the natural habitat. The growth of a seedling in the wild can vary dramatically compared to that of a seedling in a controllable environment. Certainly ex situ experimental work can reveal a great deal about important biological and ecological factors, but the combination of all environmental influences in the field combined with their unpredictable, fluctuating nature leads to the necessity of studying the seedling in its native surroundings. The effects of ecological and microhabitat features such as light, temperature, moisture, nutrient availability, disturbance, predation, disease, mycorrhizal associations, etc. on the growth and health of the seedling in the natural habitat are important in understanding which features are critical in seedling development.

33. Study cultivation requirements. In controllable environments such as those offered in the laboratory

and/or greenhouse, various aspects of plant biology and ecology can be studied singly or in different combinations without the synergistic, and thus often unassignable as to cause, effects of the numerous influences present in the natural habitat. Although ex situ work produces great strides in the knowledge of the species, all such work must be reviewed and possibly redone in the field, to address the real life situation. Research on cultivation requirements is also of vital importance in the establishment and long-term preservation of cultivated populations and seed banks. Initial work on cultivation has begun at the Desert Botanical Garden and Sul Ross State University, and preliminary results are available on a few aspects of germination and seedling growth. Task 213, the research component of the cultivation and seed bank programs advocated in this recovery plan, calls for solid research design and data gathering as part of the program's routine maintenance and propagation. Thus many of the research subjects between tasks 213 and 33 overlap. Facilities charged with maintaining the species in cultivation may not have the equipment, personnel, or time to perform the work outlined in tasks 213 and 33. Task 213 is meant to encourage propagators to keep adequate documentation on routine functions performed during cultivation and maintenance of collections. Task 33, on the other hand, allows research to proceed more quickly than routine duties may allow and notes that some subjects may be more effectively covered by other institutions.

331. Examine characteristics of seed biology including viability, longevity, dormancy, and germination requirements under controlled conditions. Seeds are currently in storage at the National Seed

Storage Lab and the Desert Botanical Garden. Part of the normal maintenance and care of these collections should eventually provide information on viability, longevity, dormancy, and germination requirements. However, data may be needed sooner than the typical seed storage program would provide. Also, research on seed production and the effect of varying conditions on seed biology are not part of a normal seed storage program. The effects of temperature, moisture, substrate, and light on seed set, viability, longevity, dormancy, and germination require additional experimentation. Results from ex situ research aids in seed biology study in the field, as well as in the long-term maintenance of propagated populations.

332. Delineate cultivation techniques from seedling to reproductive adult stages and identify critical phases. The transition from seedling to reproductive adult is often long and difficult, and many individuals die in cultivation, particularly at the seedling phase. All standard and special cultivation methods should be explored to make the propagation of the species as successful as possible. Critical periods, such as times of high mortality in the growth of the species, should be determined and any techniques for increasing survival should be described. For example, researchers have noted high seedling mortality during transplanting. Hughes (Sul Ross State University, pers. comm., 1993) has increased transplant survival by refrigerating plants for a few hours before transplanting. Recording and sharing cultivation techniques is extremely

important to establishing and maintaining cultivated populations.

333. Investigate other propagation techniques. All plants presently in cultivation have been grown from seed. Various other methods of propagation exist. Root or stem cuttings and micropropagation (tissue culture) techniques should be tried. Such methods may be desirable when a particular genetic entity is needed for possible augmentation or new population establishment.

4. Identify and search potential habitat. Although much of the potential habitat was identified and surveyed during the course of the status report, due to the isolated nature of the habitat and private landholdings in this section of the state, additional areas of potential habitat may have been overlooked. All apparently suitable habitat should be systematically cataloged and evaluated to accurately determine the range and distribution of the species and to aid in population viability analysis, management plan development, potential establishment of new populations within this historic range, long-term protection and recovery. Knowledge gained through task 31 should be valuable here.

41. Identify potential habitat through use of maps, photographs, and knowledgeable individuals. The habitat of Cryptantha crassipes is quite unique, simple to describe, and easy to recognize. Although the specific formation is not on many geologic maps, the surrounding upper and lower formations are mapped with a greater frequency, and areas where they occur require further investigation. While aerial black and white photographs were examined during the status report,

updated, color, or infrared photos may now be available. Also, more thorough and intensive inspection of a larger area may reveal additional sites to survey. Persons knowledgeable of the area such as landowners, residents, county agents, Soil Conservation Service personnel, wildlife biologists, game wardens, researchers, and others may be aware of similar sites and even new populations of the species.

42. Survey identified sites for existing populations and potential sites for establishment of new populations. Many sites may appear perfectly capable of supporting Cryptantha crassipes, and yet the species is not there. Such sites may be appropriate for potential establishment of new populations if they are within the historic range of the species. All such areas should be carefully and thoroughly evaluated in light of any research on suitable habitat characteristics.

5. Evaluate the feasibility of augmentation and/or establishment of new populations. To meet the currently recommended recovery criteria, either more individuals and/or populations of Cryptantha crassipes will have to be found, or augmentation and possibly reintroduction will have to occur. The feasibility of these approaches is not known. Presently known populations may be occupying all available space, and the addition of more individuals may produce negative results. Areas that appear to be suitable but unoccupied habitat may be lacking in some as yet unidentified characters. Thus, habitat may not be available for establishment of new populations. Additionally, appropriate propagated plant materials may not be available for augmentation or reintroduction. Currently, plants have been raised in cultivation from seed with some success, but long-term cultivation has not been achieved, nor has

transplantation of various age classes been attempted. Augmentation and reintroduction are expensive both in terms of money and labor. Such experiments also require many years to even reach an evaluation stage. Thus, long-term commitments are essential when considering the feasibility of such transplantation experimentation. Only when such efforts are known to be needed to recover the species (that is, that site management and protection techniques alone are not sufficient) should such activities be undertaken. In addition, augmentation and reintroduction should be demonstrated to be feasible (that is, suitable unoccupied habitat, propagated seeds or plants, and long-term support are known to be available) before these methods should be tried.

51. Determine if known populations require augmentation and if the habitat can support more individuals. If, after demographic and genetic studies, a population is known to be deficient in numbers of individuals, age structure, and/or genetic composition with respect to the maintenance of population and/or genetic viability, an experimental augmentation program may be considered. The demographic structure and genetic variability required for population viability should be known before planning begins.

52. Develop and establish an experimental program for augmentation and/or establishment of new populations. Augmentation and/or establishment of new populations are costly, labor-intensive experiments that rely on extensive research, both in selecting the proper natural habitat and in preparing adequate amounts of demographically and genetically suitable propagative materials. To date, most transplantation attempts of rare plants have met with failure, and experimentation

with augmentation and reintroduction is still in its infancy. Any plans for such actions require a great deal of study and review to be certain they are necessary and appropriate. Guidelines should be developed with realistic goals and measurable objectives. The experimental program should address biological considerations (such as reproduction, demographics, genetics, habitat requirements, and threats), technical and logistical problems (such as site selection, and availability of more than sufficient propagative material that is disease- and insect-free, demographically and genetically representative, well documented, and non-destructively collected), and administrative concerns (such as guaranteed site protection and access, financial support, and labor supply).

53. Monitor experimental program results and evaluate the feasibility of augmentation and/or new population establishment on a larger scale. Because any augmentation or reintroduction should be viewed as experimental, the altered or new population should not be considered successful until it is established, reproductive, self-perpetuating, and demonstrated to be demographically and genetically viable. Until such work has proven that it is a practical, cost-effective means of recovery, additional experimentation should be avoided unless the survival of the species is at risk. Experimental populations should be frequently and intensively monitored to check not only for survival, but also to determine critical periods in the establishment of a self-perpetuating population. Such monitoring could provide insights for other research programs. An augmentation or reintroduction program should be evaluated at least annually to determine if

the experiment is meeting the guideline objectives. If not, the program should be revised or discontinued.

6. Initiate an augmentation and/or new population establishment strategy, if required and feasible. If the experimental population has established itself as self-perpetuating, demographically and genetically viable, and if the experiment was labor- and cost-effective and is scientifically accepted as contributing to the recovery of the species, a larger-scale strategy for augmentation or reintroduction should be considered for certain sites. During previous research, sites requiring augmentation or providing suitable unoccupied habitat for establishment of new populations should have been identified and evaluated. The guidelines and experimental program developed during the original study should be reviewed and revised for use in the large-scale effort. Each augmented or reintroduced population should be monitored with the same level of effort as the original experimental population.

7. Encourage public interest and concern for the species and its preservation. In order for recovery efforts to succeed, area landowners and other local residents must take an interest in the species and be concerned for its long-term survival. Task 1 provides for establishing good communication with landowners and developing a cooperative conservation program. By acquiring the understanding and trust of key landowners identified in task 1, acceptance of protection for the species by the general community should be much easier. Local media coverage should be encouraged and simple printed outreach materials (such as brochures, etc.) should be produced to spread the message of conservation of this unique species and its habitat. Where welcome, guided tours stressing the importance of the species and its preservation might be arranged with

landowners to allow the public to observe the species in the wild. While the greatest need for public understanding and support is in the local area, other Texans should be educated about the species and its needs as a part of their natural heritage.

8. Develop a post-recovery monitoring plan. Once the species meets the recovery criteria, the species should be proposed for delisting and a post-recovery monitoring plan should be developed. Such a monitoring plan should track all populations in the wild, and last for at least five years (as required by the Endangered Species Act as amended in 1988) or a longer period if species monitoring and research demonstrate it is necessary.

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III. IMPLEMENTATION SCHEDULE

The following implementation schedule outlines actions and estimated costs for the Cryptantha crassipes recovery program. It is a guide for meeting the objectives discussed in Part II of this Plan. The schedule indicates task priorities, task numbers, task descriptions, duration of tasks, responsible agencies, and estimated costs. These actions, when accomplished, should bring about the recovery of Cryptantha crassipes and protect its habitat. It should be noted that the estimated monetary needs for all parties involved in recovery are identified for the first three years only, and therefore are not reflective of total recovery costs. The costs estimated are intended to assist in planning. This recovery plan does not obligate any involved agency to expend the estimated funds. Though work with private landowners is called for in the recovery plan, private landowners are not obligated to expend any funds.

Task Priorities

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 1• - An action that by itself will not prevent extinction or an irreversible decline, but which is necessary to carry out a task that is a priority 1 as defined above.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to meet the recovery objective.

Abbreviations Used

CPC - Center for Plant Conservation
FWS - U.S. Fish and Wildlife Service
  ES - Ecological Services
  LE - Law Enforcement
  RE - Realty
SCS - Soil Conservation Service
TNC - Texas Nature Conservancy
TPWD - Texas Parks and Wildlife Department

TERLINGUA CREEK CAT'S EYE R. ..RY PLAN IMPLEMENTATION SCHEDULE

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				FWS						
				REGION	PROGRAM	OTHER	YEAR 1	YEAR 2	YEAR 3	
1	11	Identify landowners with populations or individuals of Cryptantha crassipes	2	2	ES TNC TPWD		2.0 .5 .5	1.0 .25 .25		Necessary for tasks 121, 122, 13, 14, 16, 211, 3, 4, 5, and 7.
1	121	Work with landowners to establish sites protected from existing and future threats	3	2	ES TNC TPWD		3.0 .5 1.0	3.0 .5 1.0	3.0 .5 1.0	TNC landowner liaison helpful. Necessary to tasks 122, 123, 52, and 6.
1	122	Collaborate with landowners to establish short-term management actions that adequately protect the species	2	2	ES TNC TPWD		5.0 1.0	3.0 0.5		Necessary for tasks 123, 52, and 6.
1	13	Explore the possibility of land trade or purchase from willing sellers at fair market value of tracts supporting significant numbers of Cryptantha crassipes	5	2	ES RE TNC TPWD					Cost dependant on tract sizes, availability of land for trade, and location of willing sellers. Estimated price $100/acre. Helpful to tasks 123, 2, 3, and 52.
1	14	Ensure compliance with applicable Federal and State laws and regulations	ongoing and contin-uous	2	ES LE TPWD		2.0 1.0 2.0	2.0 1.0 2.0	2.0 1.0 2.0	
1	15	Monitor populations for general condition, reproductive success, and other factors that would assist in management	ongoing and contin-uous	2	ES TPWD		5.0 5.0	5.0 5.0	5.0 5.0	Needed for tasks 122, 123, 16, 315, and 52. Helpful to most of task 3. Necessary to detect rapid decline.
1	211	Collect propagative material for cultivated populations and seed storage banking	5	2	ES SCS CPC		5.0 0.5 1.0	3.0 0.5 1.0	1.0 0.5 0.5	Necessary for tasks 212, 213, 331, 332, 333 and 52. SCS plant materials center and CPC member gardens are potential cooperators.
1	212	Maintain and monitor propagative material in cultivated populations and seed storage banks	ongoing and contin-uous	2	ES SCS CPC		5.0 0.5 1.0	2.0 0.5 1.0	1.5 0.5 1.0	Necessary for tasks 213, 331, 332, 333, and 52. SCS plant materials centers and CPC member gardens are potential cooperators.
1•	213	Conduct research based on needs and opportunities of the cultivation program	ongoing	2	ES SCS CPC		1.0 0.5 1.0	0.5 0.5 0.5	0.5 0.5 0.5	Needed for task 212; coordinate with tasks 331 and 332.

TERLINGUA CREEK CAT'S EYE RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				FWS						
				REGION	PROGRAM	OTHER	YEAR 1	YEAR 2	YEAR 3	
1•	3211	Assess present demographic composition and determine viable population structure	5	2	ES	 TPWD	5.0 1.0	5.0 1.0	5.0 1.0	If low viability is found, tasks 51, 52, 53, and 6 might be elevated to priority one. Necessary to tasks 123, 51, 52, 53, 6 and 8.
1•	3212	Assess present genetic composition and determine requirements for genetic viability	3	2	ES		5.0	5.0	5.0	If low viability is found, tasks 51, 52, 53, and 6 might be elevated to priority one. Necessary to tasks 123, 51, 52, 53, 6, and 8. Helpful to task 211.
1•	322	Describe phenology and identify critical stages	5	2	ES	 TPWD	5.0 1.0	5.0 1.0	5.0 1.0	Necessary for tasks 122, 123, 211, 16, 3142, 3143, 51, 53, 6 and 8.
1•	3231	Study pollination biology	2	2	ES	 TPWD	5.0 1.0	5.0 1.0		Necessary for tasks 122, 123, 212, 51, 52, 53, 6 and 8. Helpful to task 315.
1•	3232	Ascertain modes of reproduction and the contribution of each type to the population	3	2	ES	 TPWD	6.0 2.0	6.0 2.0	6.0 2.0	Necessary for tasks 122, 123, 212, 32, 35, 51, 52, 53, 6 and 8. Helpful to task 333.
1•	3233	Examine aspects of seed biology in the natural habitat	5	2	ES	 TPWD	2.0 0.5	1.0 0.5	1.0 0.5	Necessary for tasks 211, 212, 123, 16, 51, 52, 53, and 8.
1•	3234	Study seedling biology and ecology in the natural habitat	3	2	ES	 TPWD	3.0 1.5	1.0 0.5	1.0 0.5	Necessary for tasks 123, 211, 212, 51, 52, 53 and 6.
2	123	Work cooperatively with landowners to develop and implement a long-term management plan for each population	5	2	ES	 TPWD			2.5 1.0	Starts after short-term plans. Necessary to tasks 6 and 8.
2	16	Assess and revise management plans regularly to address the needs of the species and the landowners	every 2-3 years	2	ES	 TPWD				Not initiated until year 5 or 6.
2	215	Plan for the dissemination and disposal of live plant material	1	2	ES	 CPC SCS TPWD	.5 .5 .25 .25			Needed to protect integrity of genome and protect against wasted resources.

TERLINGUA CREEK CAT'S EYE R. ..RY PLAN IMPLEMENTATION SCHEDULE

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				FWS						
				REGION	PROGRAM	OTHER	YEAR 1	YEAR 2	YEAR 3	
2	22	Coordinate and incorporate results from propagation program with other research efforts	ongoing and contin-uous	2	ES TPWD CPC		0.5 0.5 0.5	0.5 0.5 0.5	0.5 0.5 0.5	Needed for tasks 211, 212, 213, 52, 53, and 6.
2	311	Evaluate climate	3	2	ES TPWD		3.0 0.5	3.0 0.5	1.0 .75	Needed for tasks 123, 41, 51, 52, and 6.
2	312	Determine exact geologic and edaphic features	2	2	ES SCS		3.0 0.5	3.0 0.5		Needed for tasks 123, 41, 51 and 6.
2	313	Study community structure and associated species	2	2	ES TPWD		8.0 2.0	8.0 2.0		Needed for tasks 122, 123, 41, 51, 52, and 6.
2	3141	Determine successional stage	3	2	ES TPWD		5.0 1.5	5.0 1.5	5.0 1.5	Needed for tasks 123, 41, 51, 52 and 6.
2	3142	Evaluate species dependence on natural phenomena	5	2	ES TPWD		5.0 1.0	5.0 1.0	4.0 0.5	Needed for tasks 123, 41, 51, 52, 6 and 8.
2	3143	Study the response of the species to disturbance	5	2	ES TPWD		6.0 2.0	5.0 1.0	4.0 0.5	Needed for tasks 123, 3142, 41, 52 and 6.
2	315	Study beneficial and negative interactions with other species	3	2	ES TPWD		5.5 1.5	5.5 1.5	5.5 1.5	Needed for tasks 123, 3142, 41, 51, 52 and 6.
2	331	Examine the characteristics of seed biology under controlled conditions	5	2	ES CPC SCS TPWD		2.0 0.5 0.5 0.5	1.0 0.5 0.5 0.5	1.0 0.5 0.5 0.5	Needed for tasks 212 and 52. Coordinate with tasks 213 and 22. SCS and CPC are potential cooperators.
2	332	Delineate cultivation techniques from seedling to reproductive adult stages and identify critical phases	3	2	ES CPC SCS TPWD		3.0 0.5 0.5 1.0	1.5 0.5 0.5 0.5	1.5 0.5 0.5 0.5	Needed for tasks 212, 52, and 6.
2	333	Investigate other propagation techniques	3	2	ES CPC TPWD		3.0 0.5 1.0	3.0 0.5 1.0	3.0 0.5 1.0	Needed for tasks 212, 52, and 6.
2	41	Identify potential habitat								Incorporates information from task 31. Needed for tasks 42, 52 and 6.
2	42	Survey identified sites for existing populations and for potential sites for establishment of new populations	3	2	ES TPWD		4.5 1.5	4.5 1.5	4.5 1.5	Needed for tasks 11, 14, 52 and 6.

TERLINGUA CREEK CAT'S EYE RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				FWS						
				REGION	PROGRAM	OTHER	YEAR 1	YEAR 2	YEAR 3	
2	51	Determine if known populations require augmentations and if the habitat can support more individuals	5	2	ES	 TPWD	3.0 1.0	3.0 1.0	2.0 0.5	Depends on outcome of task 3 research. Needed for task 52.
2	52	Develop and establish an experimental program for augmentation and/or establishment of new populations	8	2	ES	TPWD				Necessary for task 6. Should not be initiated prior to analysis of data obtained in tasks 3211, 3212, 312, 313, 3141.
2	53	Monitor experimental program results and evaluate the feasibility of augmentation and/or new population establishment	1	2	ES	TPWD				Follows completion of task 52.
2	6	Initiate an augmentation and/or new population establishment strategy if required and feasible	10	2	ES	TPWD				Depends on outcome of tasks 52 and 53.
2	7	Encourage public interest and concern for the species and its preservation	ongoing and contin-uous	2	ES	 TPWD	5.0 1.0	1.0 1.0	1.0 1.0	Needed for tasks 121, 122, 123, 13, and 14. Helpful to task 42.
3	214	Develop data collection guidelines and promote information sharing for conservation collection	ongoing	2	ES	CPC SCS TPWD	2.0 0.5	0.5 0.25	0.5 0.25	Makes data comparable and prevents duplication of effort. Needed for tasks 211, 212, 213, 215 and 22.
3	8	Develop a post-recovery monitoring plan	2	2	ES	TPWD				
Totals							161	134.75	104.50	

IV. APPENDIX

Summary of Comments Received on the Draft Terlingua Creek Cat's-Eye Recovery Plan

In August of 1993, the Service distributed 63 copies of the draft recovery plan to landowners, recovery team members, agencies, academic researchers, botanical gardens, international officials, conservation organizations, agricultural producer organizations, and interested individuals. In addition, 15 letters were distributed notifying addressees that the plan was available for public review and comment. Comments were received from the four respondents listed below.

Dr. Kent E. Holsinger, Department of Ecology and Evolutionary Biology, The University of Connecticut

Mr. Joe Ideker, The Native Plant Project, Edinburg, Texas

United States and Mexico International Boundary and Water Commission

U.S. Department of the Interior, National Park Service, Big Bend National Park

All comments were considered when revising the draft plan. The Service appreciates the time that each of the commenters took to review the draft and to submit their comments.

The comments discussed below represent a composite of those received. Comments of a similar nature are grouped together. Substantive comments that question approach, methodology, or financial needs called for in the draft plan, or suggest changes to the plan, are discussed here. Comments received that related to the original listing decision, perceived value of this species, or general comments about the Endangered Species Act that did not relate to the Terlingua Creek cat's-eye are not discussed here. Comments regarding simple editorial suggestions such as better wording or spelling and punctuation changes, errors in addition, etc., were incorporated as appropriate without discussion here.

All comments received are retained as a part of the Administrative Record of recovery plan development in the Austin, Texas Ecological Services office.

Comments Related to Format

Comment: A color xerox of the plant and its habitat would be helpful in helping others identify the plant and its habitat.

Response: While color illustrations would be desirable, inclusion of them is cost prohibitive.

Comment: Is the numbering system for the outline of recovery actions an agency-wide standard? We suggest using a combination of numbers and letters for easier reference.

Response: The system is standard. There are a number of opinions about how to best represent subtasks in step-down outlines, but no revision to the format has yet been approved.

Comments Related to Costs

Comment: How are the total estimated costs derived? There is an estimate of costs for years 1994 through 1996 but not for succeeding years. The Recovery Plan should discuss how these costs were derived, as well as the probable source of funding.

Response: As noted in the first paragraph of the implementation schedule, costs are included for the first three years only, are not reflective of total recovery costs, and are given only as estimates to assist in planning. There is great variation in how specified tasks might be achieved and their associated costs. For example, a needed research task might be achieved through voluntary effort, graduate student research, or contract with professionals. It is also difficult to predict in advance what sources of funds may be available. Estimates are provided as a general aid to planning. The implementation schedule also identifies parties who would likely be involved with recovery through the funding or implementation of tasks. However, actual involvement will depend on funding availability and other workload priorities. With changes in costs in succeeding years almost certain, the greatest usefulness in estimating needs will be in the next few years.

Full recovery costs are estimated task by task on the same general basis, extrapolated over projected time needed for recovery, and included in the executive summary. They are meant to give a gross estimate of the magnitude of the recovery effort. One objective in recovery plans is to keep

them brief and readable, and we limit material included to that which is most useful. As total cost estimates are so preliminary, it is not believed necessary to cover them in detail in the actual plan.

Comment: The cost expected to be incurred by landowners or the cost of anticipated compensation to landowners should be included in the estimated cost of recovery, if that has not already been done.

Response: We do not anticipate that landowners participating in recovery efforts will incur significant costs. Participation by landowners is voluntary and would consist mainly of exercising sensitivity to the plants present on their properties in development planning or everyday management activities. The implementation schedule comment for task 13, exploring the possibility of land trades or purchases from willing sellers for significant tracts, notes that a total estimate is not possible until significant tracts are identified. It also notes that cost would vary by tract, with an average estimate of about $100 per acre. Acquisition is not believed to be necessary or advisable for all needed recovery areas, as many landowners may be willing and able to participate in recovery efforts with no significant changes to their current or projected use for their tract.

Comment: What is the significance of this species from a medicinal, horticultural, or economic standpoint? The importance of this species needs to be stated in the recovery plan, as well as the significance of extinction.

Response: We are not aware that this species has ever been evaluated for medicinal, horticultural, or economic value. However, as we learn more about it, some of these values may become apparent. Under the Endangered Species Act, the Service is charged with protecting species from extinction because of their "...aesthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people." This declared significance is the reason for their protection and efforts to recover them noted in the plan.

Comments Regarding Landownership and Landowner Permission

Comment: Several tasks appear to assume that access to the sites is available. The reader gets the impression that few landowners are known and, if that is the case, access or

collection of plant materials without landowner permission would be considered trespass.

Response: The Service does not authorize, encourage, or condone trespass. Task 11 (a priority 1 task) calls for the identification of landowners. Tasks 121, 122, and 123 call for working directly with landowners to establish protected sites and develop management plans. Other tasks involving private lands are predicated on working in cooperation with landowners as stated in these tasks and the recovery strategy. No work is intended to be done without landowner permission and cooperation.

Comments Regarding Specific Tasks

Comment: Task 4 should be a higher priority and appear higher in the list of tasks.

Response: Task 4 is a priority 2 because the comprehensive status survey that was completed in 1987 has given us an assessment of the condition of the species. The greatest return on our efforts for the species now is judged to come from work with existing sites. It is hoped additional survey work may yield a few additional sites, but is not expected to locate enough to alleviate concerns about the potential for extinction. Because of this, additional surveys are scheduled to occur later in the recovery effort. Searches will probably be more fruitful after additional habitat characterization work is done and ideas regarding the need for restoration work are formulated. These activities will help refine the area to be searched and the factors usable in identifying potential habitat.

Comment: If Cryptantha crassipes is self incompatible, monitoring sex ratios is very important, especially in small populations. Skewed sex-ratios can significantly reduce the reproductive capacity of heterostylous populations.

Response: This is true, and tracking sex-ratio has been added specifically to the monitoring task.

Comment: What evidence is there that the pollinator is also a narrow endemic? If it is, it is obviously critical that the pollinators' populations be managed for recovery.

Response: Preliminary studies have revealed that small native bees are working the plants, though it has not yet been established that these are the instrumental pollinator.

Many small native bees are relatively narrow endemics, and it is precisely because management of the pollinator could be critical that this possibility is raised in the life history section. Task 316 recommends that pollinators be examined and appropriate planning done to provide for any necessary management to meet species needs.

Comment: Why are the results of the two germination trials so different? Which represents the best guess about future success rates? This could have a large impact on the number of seeds that need to be collected for representative samples in off-site collections.

Response: The reasons for this are unclear and a cause for concern, which is the reason that tasks 331 and 3233 call for additional studies in this area.

Comment: If the germination success rates of Hughes are reproducible, I see little reason to worry about developing other propagation techniques. It should be a low priority.

Response: As the reproducibility of these results is not yet clear (see the comment above) and abundance of seed set and availability of seed for increasing stock for research and restoration is not clear, task 333 is included to allow for this activity, if appropriate. The Service has designated this as a priority 2 task, indicating it is not believed necessary to implement immediately to prevent the extinction of the species, but may be needed to prevent other negative impacts to the species.

Comment: Keeping track of the parentage of seed in the seed bank is probably not necessary. It could conceivably be useful, but little would be lost if samples from a single population were simply bulked, with approximately equal numbers of seed contributed by each plant represented in the collection.

Response: Keeping track of percentage is only recommended if it is feasible. While early research is conducted which will hopefully involve tracking individuals in populations, it is likely that this could be done without too much burden to researchers. If so, it seems advisable to take the conservative route and maintain as much information as possible rather than choosing to lump samples. Seed of known parentage, combined with information on individual fitness by population, may later prove helpful in other research efforts, or in selecting seed for restoration activities.

Comment: Seed bank collections should be used to maintain a representative sample of genetic diversity off-site. The cultivated part of the collection should be used for research, display, and education. Breeding programs for live collections that maintain a representative sample of the genetic diversity originally present are a difficult task, to be undertaken only if seed cannot be stored.

and

Comment: In addition to checking seeds for viability and longevity, you should also consider a plan for periodic replenishment of the seed bank, based on your analyses of viability of the seed bank.

Response: Task 21 was meant to be broad enough to include both seed bank and cultivated collection activities, as necessary. While a seed bank is preferable for maintaining a genetically representative collection of each population if possible, it is unclear at the present time if seed of this species can be stored successfully. Task 212 was meant to provide for monitoring, periodic testing, replenishment, or other maintenance needs as identified. Wording has been added to task 212 to clarify this. It is anticipated that both a seed bank and an institution with a cultivated collection that serves as monitor and support for the conservation collection initiative will be needed. The seed bank and cultivated collection should work in tandem, as necessary, to provide for preservation of a genetically representative collection of each population, and provide materials for research and restoration activities.

Comment: I would urge the study of genetic variability, at least as assessed by genetic or other molecular markers, as a low priority. The focus of genetic analyses should be either on the identification of adaptively significant ecotypic variation, which might provide insight into the prospects for introductions to new sites, or on the relationship between sex ratios and reproductive success. Allozyme analyses or other molecular markers are unlikely to provide any useful insights.

Response: The situation with Cryptantha crassipes has enough characteristics that could cause severe genetic problems threatening viability that the possibility cannot yet be discounted. Numbers per population are low (more than half the known sites have fewer that 100 plants), plants are very widespread even though they are obligate outcrossers, and existing populations have been fragmented. At least a preliminary evaluation should be done to eliminate the possibility that this is a serious threat. The task does

not specify any particular technique to be used, but does specify the information needed. Breeding studies, such as monitoring sex-ratio and reproductive success, and testing seed set in artificial crossing experiments, may be useful. Genetic techniques are rapidly changing, and other techniques or analyses may also be appropriate in helping evaluate whether there is cause for concern.

Comments on Recovery Criteria

Comment: Given the way the Endangered Species Act is written, I wonder whether it is ever possible to delist an endangered plant species that occurs only on private property, unless there is a permanent conservation easement on the land. The threat of development is always present.

Response: Delisting of a species is only considered for any listed species, plant or animal, if it is determined to be in good enough condition (in numbers, range, and degree of threat) that it is stable and self sustaining, and no longer considered to qualify as threatened or endangered. Recovery and evaluation criteria usually provide for reasonable fluctuations in numbers of populations and individuals. When recovery levels are achieved, it is probable that considerable cooperation and education to provide for the needs of the species have been achieved as well, for private landowners and for agencies whose projects might impact the species. The recovery effort may have involved a number of different strategies in addition to acquisition or conservation easements. Things such as changes in land management practices, restoration of habitat or populations, consultation agreements with agencies, and management agreements with landowners, developers, and public land managers may all contribute to achieving a viable population. Some of these approaches are permanent and some not. Nevertheless, it is reasonable to assume that the benefits achieved for the species in a successful recovery effort will continue, at least partly, through concern and informed stewardship. Many of the protective agreements achieved through the implementation of the Endangered Species Act will remain in effect. In addition, there are safeguards against premature or ill-advised delisting. At the time of delisting, an approved plan must be in place that provides for monitoring for a 5-year period to be certain that the species does not decline. If recovery levels cannot be maintained, action would be taken to relist the species.